Space Weather Technical Forecast

Issued on Sunday, 12 November 2023 at 01:29 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1 to G2 Minor to Moderate geomagnetic storm Expected day 1 (12 Nov), chance G3 Strong geomagnetic storm at peak. Active electron fluence Expected at GEO until this arrival.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is at Moderate levels with a solitary Moderate class flare, peaking M1.2 at 11/1729 UTC from AR3477 (Dso/Beta). Occasional C-class activity has been observed from the four sunspot groups on the disc. AR3477 saw a slow decrease in size in lead and trailer portions of the group during the period. AR3483 (Dhi/Beta-Gamma) increased in size with the development of new intermediate spots that appear to be consolidating into a larger trailer spot. A previous Delta configuration has now faded. AR3484 (Dri/Beta) and AR3485 (Cro/Beta) has seen some occasional spot proliferation, but both regions remain small at this time. AR3480 and AR3281 faded from the disc.

A filament eruption was observed to have lifted-off the northwest quadrant around 11/0600UTC, which was associated with coronal dimming and produced a CME seen in coronagraph imagery. The event is awaiting analysis for any potential Earth-directed component, though it appears unlikely. No other Earth-directed CMEs have been observed in the past 24 hours.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by ACE and DSCOVR, showed very different tendencies, but overall are felt to be reflective of the waning enhancement from a high speed stream associated with CH67/-.

With ACE measurements taken in preference, solar wind speeds fell from Elevated, around 500-550km/s to Slightly Elevated, 450km/s by the end of the period, with a declining trend. Density steadily increased from below average to reach above average levels, with a peak of 16pppc at 11/2227 UTC. The total interplanetary magnetic field strength (Bt) was steady at or below 3nT, with a varying Bz component within +/-3nT. The phi angle remained predominantly negative (towards the Sun).

The net result of the above solar wind measures was for Quiet (Kp 0-2) geomagnetic indices.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at background levels.

GOES16 high energy (greater than 2MeV) electron flux showed a diurnal oscillation at persistently High levels, peaking at 4370pfu at 11/1710 UTC. The associated 24-hour fluence gradually increased through the period, with the fluence observation at 12/0001UTC being 2.33e8 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate, with a chance of further isolated M-class flares on days 1 and 2 (12 and 13 Nov), reducing to a slight chance on days 3 and 4 (14 and 15 Nov).

Solar Wind / Geomagnetic Activity: Solar winds are currently at slightly elevated levels following the recent HSS from a coronal hole, with Quiet geomagnetic conditions. The geomagnetic forecast is dominated by the imminent arrival of the 09 Nov full halo CME, currently

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forecast to arrive early day 1 (12 Nov). G1 to G2 Minor to Moderate geomagnetic storms are expected at peak, with a chance of G3 Strong geomagnetic storm conditions, easing down into day 2 (13 Nov). Geomagnetic activity should return to mainly Quiet levels following this within a broadly slow-ambient solar wind regime.

Energetic Particles / Solar Radiation: There is a daily very slight chance of S1 or greater radiation storm conditions should any of the western solar hemisphere sunspot groups produce significant flares during the period. This risk should begin to wane from the start of the next working week as these sunspots progress onto the far side.

High energy electron flux (greater than 2MeV) is expected to continue near current (High) levels at first but should be significantly attenuated at GEO upon the arrival of the 09 Nov CME, with a roughly evens chance of Active fluence surviving into the start of the UTC day of day 2 (13 Nov). Once suppressed, there is a chance of recovery at GEO as the new UTC week develops and geomagnetic activity subsides again.

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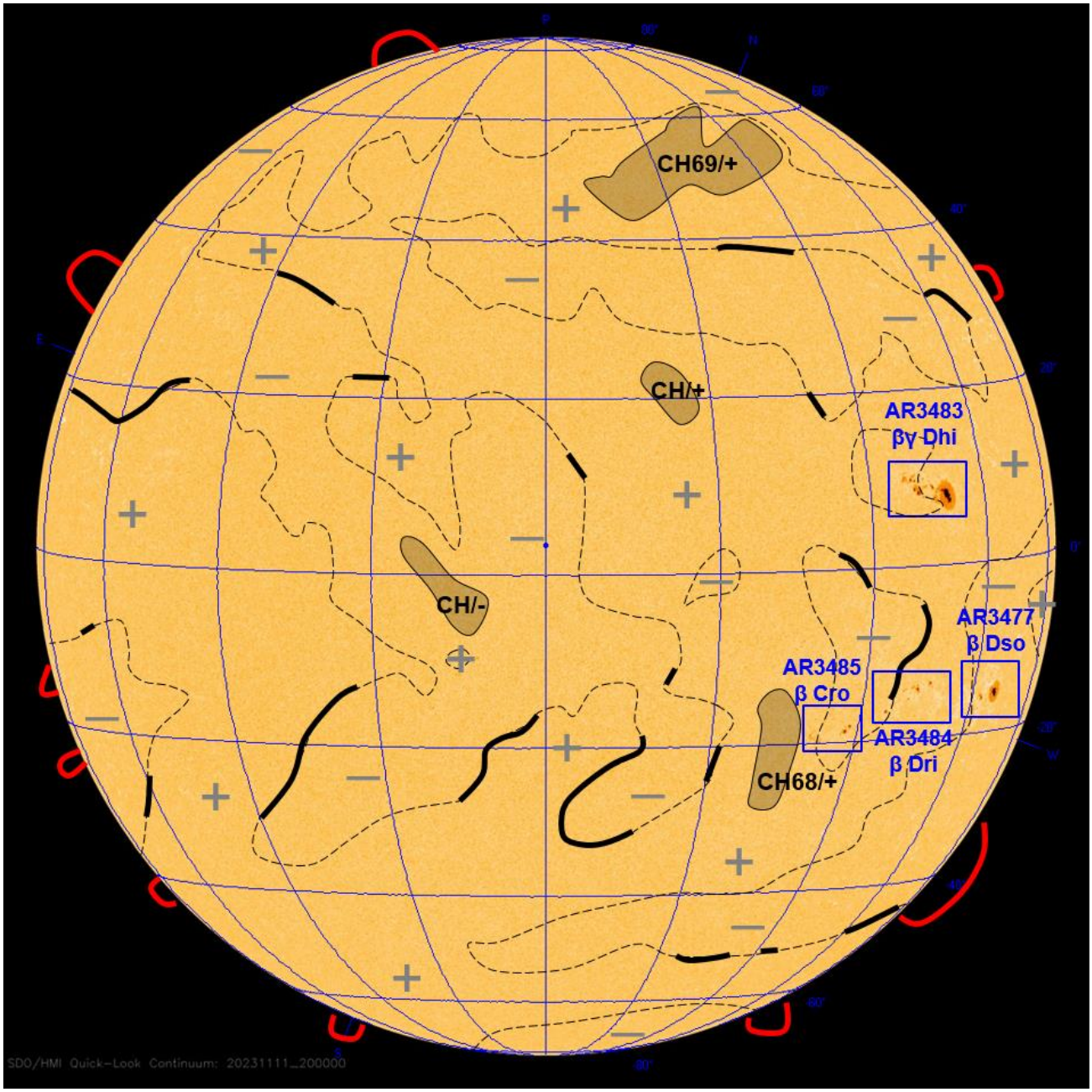
Figure 1. Solar Analysis Valid 11/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

By far the most noteworthy aspect of the coming four-day period is the imminent arrival of the 09 Nov C2 flare and major coronal dimming-associated full halo CME from near centre-disc. This feature inherently carries some uncertainty due to the very narrow perspective offered by STEREO and Lasco viewpoints, however arrival is now expected early on day 1 (12 Nov). After numerous re-analyses, a most likely arrival at 12/0001UTC. A G3/Strong Geomagnetic Storm watch is currently valid until 12/1200 UTC.

A faint and slow CME was observed leaving the sun late on 10 Nov. The source region of this CME appears to be an eruption in the southwest quadrant in the vicinity of the trio of sunspots (AR3477, AR3484 and AR3485). Initial modelling suggests that the bulk of the CME will miss ahead of Earth orbit, however there is a chance of a glancing blow on day 4 (15 Nov) with limited impacts expected.

A partial filament liftoff was observed from the northwest disc early on 11 Nov, resulting in a slow CME that appears to be directed above and ahead of Earth orbit. The CME will be modelled to confirm this assertion.

Separately from any CME effects, the persistence forecast comprises of largely Quiet geomagnetic conditions. Earth is expected to continue to exit the residual HSS of CH67/- prior to the 09 Nov CME's arrival, with no further significant recurrent or transient coronal hole features of note expected during the period. Following the arrival of the aforementioned CME, solar winds should trend to background levels again, with little change expected following this.

Initially Quiet to Unsettled conditions are expected to give way to Minor to Moderate geomagnetic storms early on day 1 (12 Nov). There is a chance of G3/Strong geomagnetic storms occurring. Activity should wane following this but with a chance of G1 conditions extending into early day 2 (13 Nov). Quiet or Unsettled activity is then expected, but with a very slight chance of Active or G1 geomagnetic storms should the CME from 10 Nov arrive at Earth on day 4 (15 Nov).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	90	20	1	5
Strong	G3	No	30	1	1	1
Severe	G4	No	5	1	1	1
Extreme	G5	No	1	1	1	1

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Met Office Space Weather Technical Forecast

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
09/1800 UTC	Full	Vicinity of AR3480, AR3484 and AR3485	Central SW	700 km/s	12/0001 UTC	Earth directed but low-moderate confidence fit for timings.
11/0633 UTC	Partial	Vicinity of AR3480, AR3484 and AR3485	Central SW	378 km/s	15/1200 UTC	Chance of a glancing impact. Low confidence, but limited impacted expected.

Radio Blackouts - X-Ray Flares:

There are currently four sunspot regions on the disc. AR3483 (Dhi/Beta-Gamma) in the northwest remains the largest group. There has been some proliferation and spreading of its intermediate portion and the numerous small umbra present may be consolidating into a larger trailer spot. The region also contains a Beta-Gamma magnetic configuration.

A complex of three regions lies in the southwest within a broad region of plage. These regions, AR3477, AR3484 and AR3485 appear to be magnetically connected. For the most part these groups appear rather simple and small, however, there has been occasional proliferation of small pores or spots, particularly with AR3484 and AR3485 that bear watching for any further development.

In terms of the overall balance of front-side region populations, AR3477 should depart later on day 2 (13 Nov) to offer a slight downturn in M-class flare risk, followed by AR3483 on day 3 (14 Nov) and AR3484 on day 4 (15 Nov), further reducing probabilities. Far-sided soundings, persistence and flux looping all suggesting limited contributions from any returning regions over the eastern limb during the period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	25	25	15	5
Very Active	R3 to R5 X Class	No	1	1	1	1

Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is at background levels.

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There is considered to be a very Slight Chance of S1 of greater radiation storm conditions during the period, owing to the numerous sunspot regions currently located in the western hemisphere. Probabilities then begin to wane from the start of the next working week as the cluster of front-side sunspots begin to cross onto the far side.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has shown day-on-day increases in response to the recent fast wind from CH67/-, but is expected to now be at its peak at High flux ahead of the imminent arrival of the 09 Nov CME.

Active electron fluence is Expected to continue on day 1 (12 Nov) with levels in the Van Allen belts then very likely to be attenuated upon the arrival of the 09 Nov CME, with fluence perhaps just surviving at Active levels into day 2 (13 Nov) as they fall away rapidly, but from an elevated starting point. Geomagnetic activity should then hold levels at GEO for at least 24 hours before an uncertain degree of recovery of the Van Allen belts and electron counts into the new working week.

MOSWOC REFM is not felt to be a useful guide in this instance given the overwhelming reliance of the forecast on recurrent activity.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	50	20	40
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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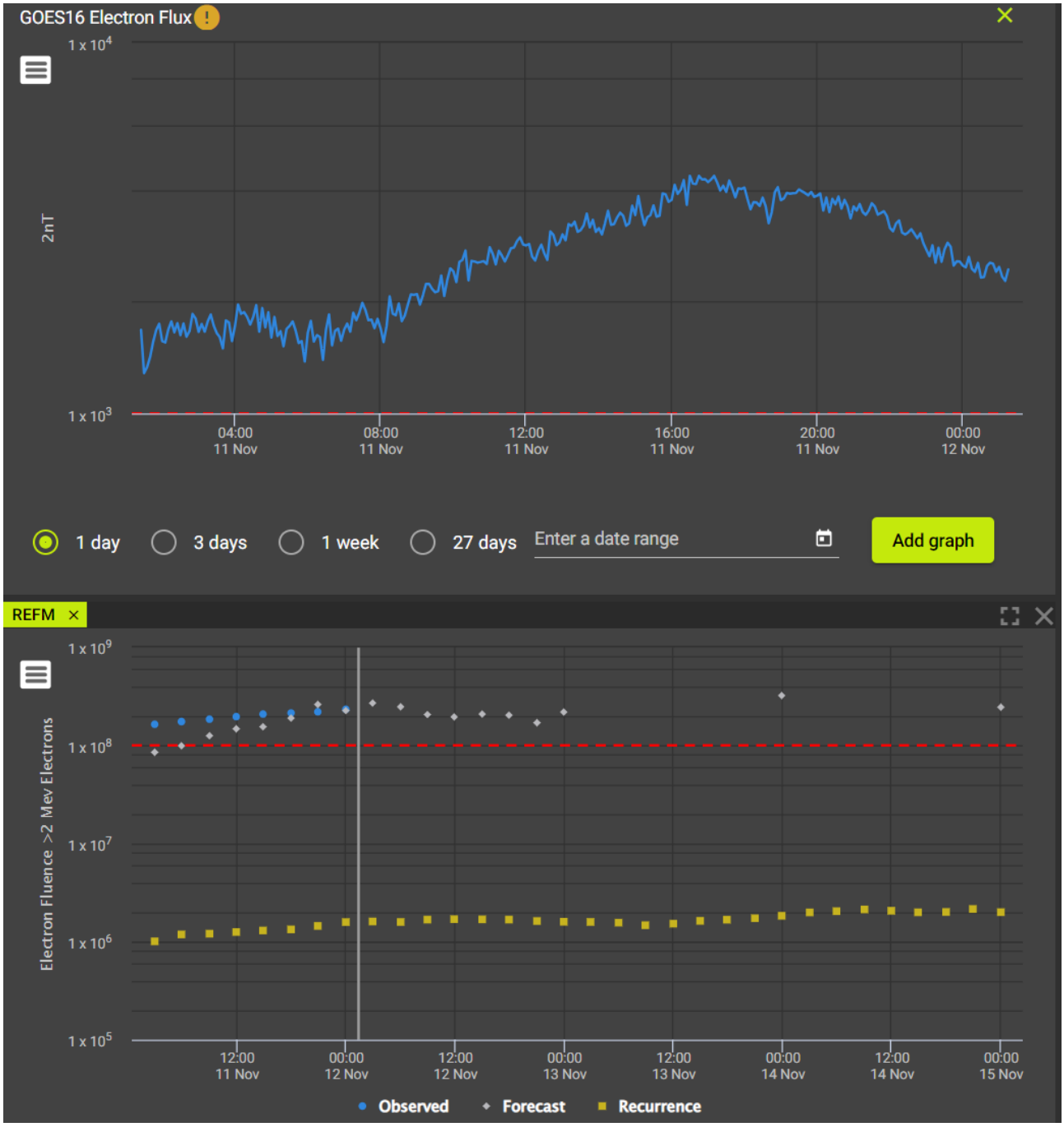
Figure 2: GOES 16 >2MeV Electron Flux (top) and MOSWOC Fluence and Recurrence forecast (below)



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